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SEMICONDUCTORS AND THEIR ELECTROPHYSICS

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ABSTRACT

This article presents in the electrical properties of semiconductors depend on the interconnection of atoms in the crystal and the connection of electrons with atomic nuclei, as well as the formation process of the electron-hole pair.

Keywords: metal, semiconductor, dielectric, electron, hole, energy, atom, crystal, charge, motion, voltage, silicon, valence band, conduction band.

INTRODUCTION

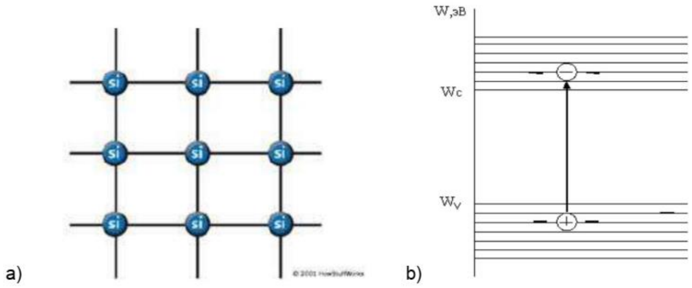
Substances whose conductivity value is between metals and dielectrics are called semiconductors. Semiconductors include a large number of solids. The most common semiconductors are germanium and silicon, and their electrical properties are almost identical. The electrical properties of semiconductors depend on the interconnection of atoms in the crystal and the binding of electrons to the nuclei of atoms. In semiconductors, these bonds are very strong, and therefore they have very few free electrons. But some of these bonds can be broken artificially.

For example, when a semiconductor is heated, its electrons are given additional energy, and some of them leave their atoms and become free electrons [1-5]. These electrons move randomly in different directions in the semiconductor in the absence of an external electric field. It has lost its electron and therefore a positively charged atom does not move like an electron in a semiconductor, but oscillates in an intermediate position in a crystal. It can be considered that instead of the electrons released from their bonds, empty spaces are formed, which is called holes. Naturally, electrons in a semiconductor number is equal to the number of holes. When an electron comes into the zone of influence of an electric field of a hole, the hole captures the electron, as a result, the negative charge of the electron is neutralized by the positive charge of the hole, and a neutral atom is restored [6-19].

Such recombination of holes and electrons is very fast, but no less than new electrons and holes are formed, the average number of which is a constant value under normal conditions for a given semiconductor.

DISCUSSION AND RESULTS

If an electric voltage is applied to the semiconductor crystal, then an orderly movement of electrons occurs, that is, an electric current flows through the semiconductor. It is created by the electron and hole conductivity of the semiconductor, and this conductivity is called specific conductivity because it depends on the semiconductor material. Almost 97% of semiconductor electronics products are based on silicon. If the semiconductor crystal does not contain inclusions at all and there are no defects in the structure of the crystal lattice (empty nodes, lattice shifts, etc.), such a semiconductor is called special and is denoted by the letter.



1-Fig. A simplified model of a silicon lattice without an insert (a) and its band energy diagram is shown in (b).

Figure 1.1 shows that in a silicon crystal, the four valence electrons of its atom are connected to the four electrons of the neighboring silicon atom, forming a solid eightelectron shell (straight line). At a temperature of 0 K, free charge carriers do not exist in such a semiconductor. But when the temperature increases or the light is lowered, some of the covalent bonds are broken, and the valence electrons gain enough energy to move to the conduction band (Fig. 1 b).

As a result, the valence electron becomes a free charge carrier, and when a voltage is applied, it participates in generating a current. As a result of the electron loss, the atom becomes a positive ion.

At the same time, an empty level is formed in the valence band, and valence electrons are allowed to change their energy, that is, to move from one allowed level of the valence band to another. Thus, it can participate in the process of vine formation. As the temperature increases, more valence electrons move into the conduction band and electrical conductivity increases.

The free energy level in the valence band or the free valence bond cavity is called a free positive charge carrier equal to the absolute value of the electron charge. The movement of the hole is opposite to the movement of the valence electron.

Thus, the breaking of the covalent bond between the atoms simultaneously leads to the formation of a hole near the free electron and the atom from which the electron has been released. The process of formation of an electron-hole pair is called the generation of charge carriers. If this process takes place under the influence of heat, it is called heat generation. The formation of an electron in the conduction band and the formation of a hole in the valence band are depicted as circles using appropriate symbols in Fig.1b. The transition of an electron from the valence band to the conduction band is indicated by the arrow.

The generated electrons and holes move randomly in the semiconductor crystal for a period of time called the residence time, then a free electron fills the incomplete bond and the bond is formed. This process is called recombination.

At a constant temperature (in the absence of other external influences), the crystal is in a state of equilibrium. That is, the number of generated pairs of charge carriers is equal to the number of recombined pairs. The number of charge carriers per unit volume, that is, their concentration, gives the value of specific electrical conductivity. Electron concentration in proprietary semiconductors is equal to the concentration of holes ($n_i = p_i$). The letters n (from the word negative) and p (from the word positive) correspond to an electron and a hole, respectively. Electrons and holes formed in a semiconductor without an input are private free charge carriers.

In a semiconductor, it is possible to artificially create conditions in which the number of electrons is not equal to the number of holes, so the transfer of charges - electrical conductivity is caused by the movement of more single-point charges: either electrons or holes. In practice, this is achieved by introducing a very small amount of relevant input into the pure semiconductor.

For example, if arsenic (As) atoms from the fifth group of chemical elements of the Mendeleev table were introduced into a germanium crystal, then one of the electrons of the arsenic atom is weakly bound to the atomic nucleus, that is, it can be considered free electron. As a result of a similar operation, in a germanium crystal, even if it remains electrically neutral, electrons remain much more than holes, and the conductivity of the semiconductor is due to free electrons, which in this case are considered the main current carriers. increases sharply. This entry is called a donor entry (donor is a Latin word meaning giver, in this case electron giver). A semiconductor with such an input is called an n- type (from the English word negative - meaning negative) semiconductor. As precursors for germanium, silicon, usually arsenic, phosphorus, antimony, etc. can be used.

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